

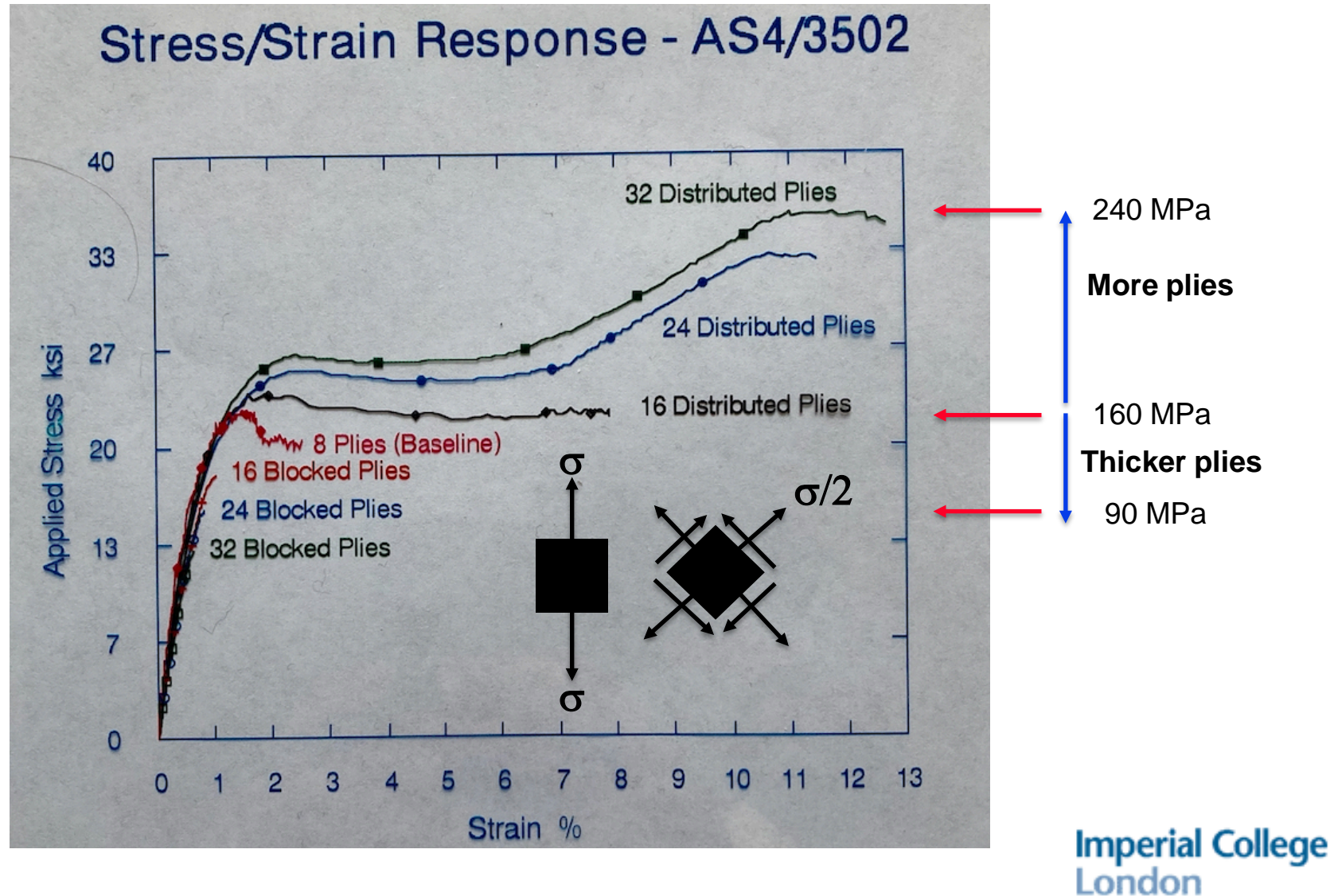
Damage, Strength and Failure in +/-45° Fibre Composite Laminates in Tension Tests

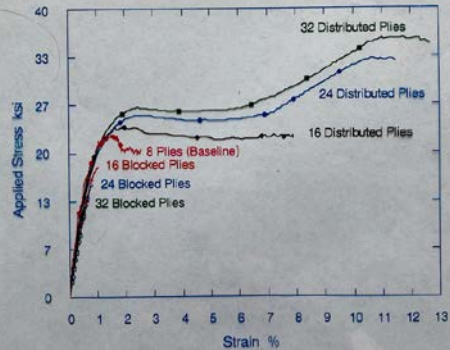
John Morton

Based on *Damage and Failure Mechanisms in Scaled Angle-Ply Laminates* by Sotiris Kellas, John Morton and Karen Jackson (ASTM STP 1156, 1993; with additional data produced by Ming-Yi Tsai.

+/-45° Tensile Tests

(8-ply baseline [+45/-45/+45-45]_s)





Observations

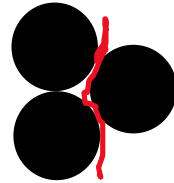
- Behaviour ranges from “brittle” to “ductile”
- Lamina tensile plus shear stresses.
- There are residual stresses (enough to cause cracking before loading)
- Non-uniform fibre distribution (local variations in volume fraction).
- Free-edge effects (influence where cracks initiate?)



Damage and failure mechanisms?

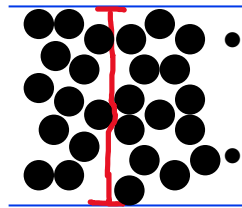
Crack initiation

Fibre-level



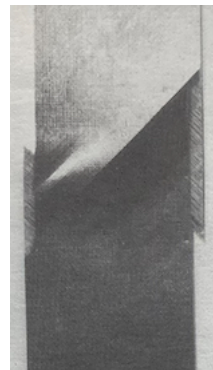
Crack Propagation

Ply-level



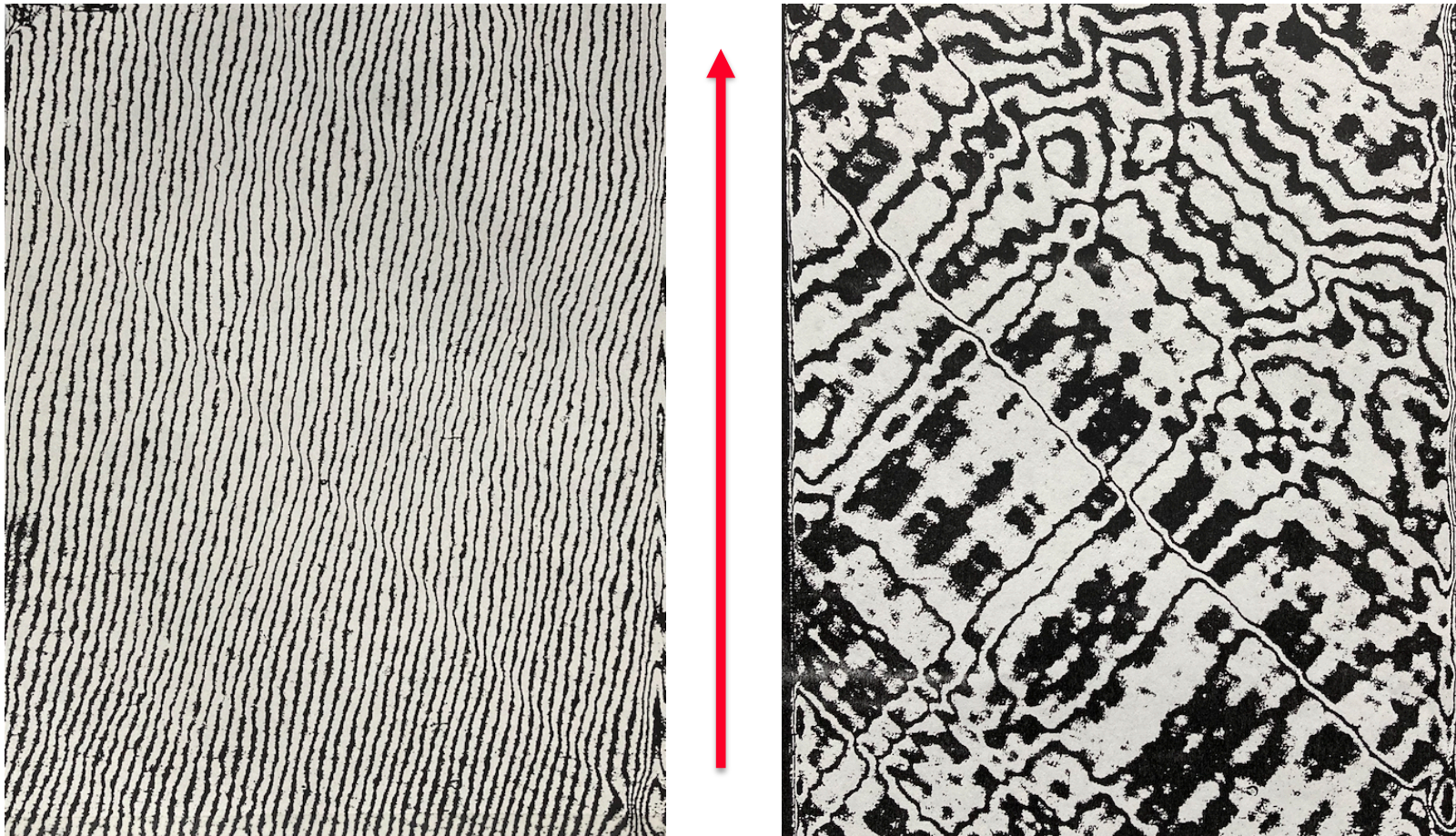
Delamination

Specimen-level

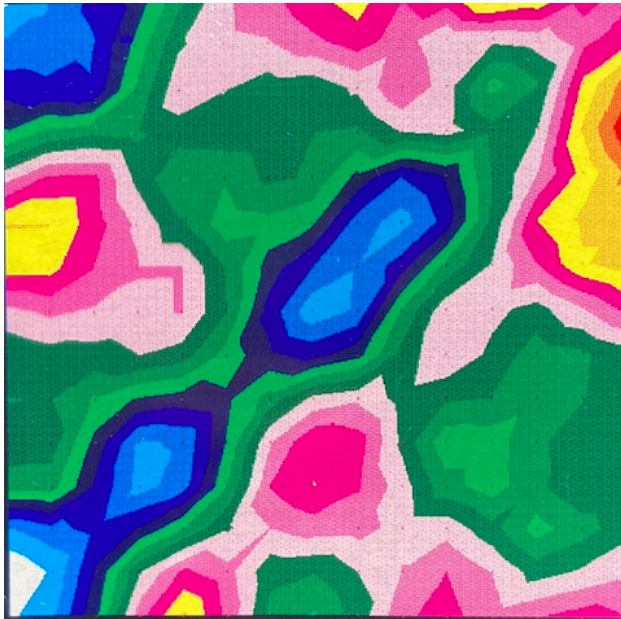


- Residual stresses initiate cracking!
- Non-uniform fibre distribution (local variations in volume fraction).
- Micron-scale cracking at touching fibres.
- Free-edge effects (where do cracks initiate?)
- Number of touching fibres is key and increases with effective ply thickness (statistical effects).
- ...and the mid-ply thickness is double the others....crack initiation
- Intra-ply crack length depends upon ply thickness and cracks end at delamination.
- "Ductility" from sliding and rotating delaminated "blocks"?

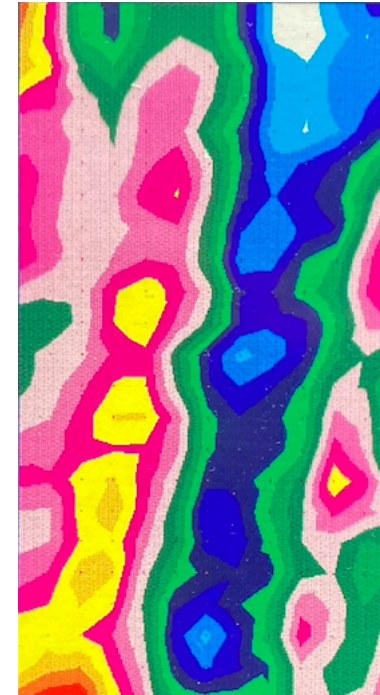
Non-uniform deformation on a macroscale (moire interferometry)



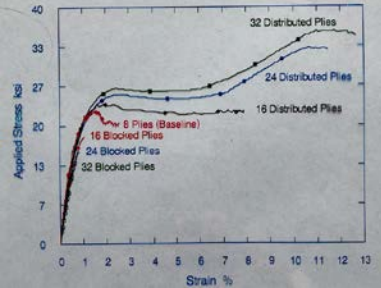
Non-uniform strains in 10° off-axis (lamina) as well as +/-45° (laminated) tests.



+/-45° tension



10° off-axis



Implications for.....

- Shear property measurement?
- Strength measurement?
- Strength definition?
- Composite modelling?
- Design?

